FA Translation

FUEL BUNDLE

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FUEL BUNDLE

[Brennstabbündel]

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Claims /1*

1. Fuel bundle with several vertical fuel rods (3), a fuel channel device (1), a lower lattice array (2), and a transition piece (4,15,25,26,35), wherein the fuel rods (3) are surrounded by the fuel channel device (1) and the lower ends of the fuel rods rest on the lower lattice array (2), while the lower lattice array and the fuel channel device are supported by the transition piece, which has an upper section that is essentially square in cross section and a lower inlet part (9,9',37) that is essentially circular in cross section, characterized in that the transition piece is provided with an exchangeable throttling element (7,7',14,22,28,40) fixed to the transition piece for throttling a reactor coolant flow flowing through the inlet part.

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* [Numbers in right margin indicate pagination of the original text.]

2. Fuel bundle according to Claim 1, characterized in that the throttling elements (7,7',14,22) rest on at least one support surface (5,6,13,23) that is pointed upwards and that is located in the transition piece.

3. Fuel bundle according to Claim 2, characterized in that the aforementioned support surface(s) (5,6,13) is/are arranged above the inlet part.

4. Fuel bundle according to one of the preceding claims, characterized in that the throttling elements are provided with several through-holes (8,20,43) for the reactor coolant flow.

5. Fuel bundle according to one of the preceding claims, characterized in that the lower lattice array (2) is connected in a force-transferring way to the throttling element (7,7',14). /2

6. Fuel bundle according to Claim 5, characterized in that the throttling element contains several legs (17), which are pointed upwards axially and which are connected in a force-transferring way to the lower lattice array (2).

7. Fuel bundle according to Claim 6, characterized in that at least two of the legs (17) have a projection (17') pointed outwards radially, while the upper, essentially square section of the transition piece is embodied with corresponding surface sections (17"), which point downwards and which contact upwards-pointing surfaces of the projections (17') pointed outwards radially.

8. Fuel bundle according to one of the preceding claims, characterized in that the throttling elements (22,28,40) are arranged in the inlet part.

9. Fuel bundle according to Claim 8, characterized in that the inlet part has at least one horizontal support surface on the inside and in that the throttling element contains a throttling disk (22,40) contacting the aforementioned support surface(s).

10. Fuel bundle according to Claim 8, characterized in that the inlet part has a threaded circular cylindrical inner surface and in that the throttling element (28) is provided with a corresponding threaded section (29), which can be screwed into the inlet part.

The invention relates to a fuel bundle according to the preamble of Claim 1. /3

The inlet part on the lower end of the fuel bundle is used for arrangement purposes in an associated opening in a tie plate, which carries several fuel bundles. The openings in the tie plate and thus the fuel bundles are each connected hydraulically to a water passage for the supply of cooling water to the fuel bundles. It is known to provide each of these water passages with a throttling element in order to be able optimally to set, among other things, the water distribution in the reactor core by distributing the amount of water flowing through a fuel bundle to the various individual groups of fuel bundles.

The invention is based on the problem of developing a fuel bundle of the type mentioned in the introduction, which provides the ability easily to adjust the reactor coolant flow through the fuel bundle, especially in connection with fuel regeneration. To solve this problem, a fuel bundle according to the preamble of Claim 1 is proposed, which, according to the invention, has the features mentioned in the characterizing portion of Claim 1.

Advantageous refinements of the invention are mentioned in the subordinate claims.

The adjustability obtained through the invention is of great significance when several fuel /4
bundles, which exhibit different hydraulic total resistance values relative to each other in the unadjusted state, are to be used in the same reactor core. This is the case, e.g., when a fourth of the total number of fuel bundles in the core are to be exchanged for fuel bundles with a lower hydraulic resistance. Then, when the new fuel bundles are inserted, a throttling element can be set for each fuel bundle so that there is an optimal or nearly optimal distribution of the total reactor cooling water flow to the individual fuel bundles, without requiring intervention in the reactor parts located underneath the fuel bundle.

The invention is to be explained in more detail with reference to the embodiments shown in the figures. Shown are:

Figure 1, a first embodiment of a fuel bundle according to the invention in partial vertical section along line I-I in Figure 2,

Figure 2, a horizontal section along line II-II in Figure 1, wherein in Figures 1 and 2 the left halves include a first alternative and the right halves include a second alternative of this embodiment according to the invention,

Figure 3, a second embodiment of a fuel bundle according to the invention in partial vertical section along line III-III in Figure 4,

Figure 4, a horizontal section along line IV-IV in Figure 3,

Figure 5, in top view a throttling element for the fuel bundle shown in Figures 3 and 4,

Figure 6, a vertical section along line VI-VI in Figure 5,

Figure 7, a third embodiment of a fuel bundle according to the invention in a partial /5
vertical section along line VII-VII in Figure 8,

Figure 8, a horizontal section along line VIII-VIII in Figure 7,

Figure 9, a fourth embodiment of a fuel bundle according to the invention in a partial vertical section through the vertical center line of the fuel bundle,

Figure 10, a fifth embodiment of a fuel bundle according to the invention in a partial vertical section along line X-X in Figure 11,

Figure 11, a horizontal section along line XI-XI in Figure 10.

In the figures, the fuel channel devices of the fuel bundle are designated 1. Each fuel bundle has sixty-four fuel rods 3, which are surrounded by the fuel channel device 1 of the fuel

bundle and are carried by a lower lattice structure 2. The lattice structure 2 contains several legs 2', by means of which the lattice array 2 is carried by a transition piece, which is mounted on a fuel bundle tie plate. In all of the illustrated embodiments, the upper end of the transition piece has an essentially square cross section, while the lower end of the transition piece is embodied as a circular cylindrical inlet part for the reactor coolant supplied to the fuel bundle.

In the alternative embodiments shown in Figures 1 and 2, the upper part of the transition piece 4 is provided with four relatively thick-walled corners. Horizontal support surfaces 5, or alternatively 6, which point upwards, are arranged in these corners for a throttling disk 7, or alternatively 7', arranged in a horizontal plane. The throttling disk 7, or alternatively 7', is embodied as a square metal plate with beveled corners and has at least eight, but preferably more (e.g., sixteen) through-holes 8. The throttling disk 7 rests on the support surfaces 5 by means of /6
four leaf springs 11 mounted on the throttling disk, while the throttling disk 7' is arranged in direct mechanical contact with the support surfaces 6. For both alternatives, the throttling disk is prevented from moving significantly vertically upwards by horizontal support surfaces 12 directed towards the throttling disk on the legs 2'.

The transition piece 4 has an inlet part 9, which is embodied on the inside and on the outside with a circular cylindrical surface, and which is provided, like the inlet parts of the other embodiments shown in the figures, with a throttling element, which consists of three uniformly distributed arms 10, which extend from the inlet part 9 and which are connected to each other at a central point.

The transition piece 4 has at least one hole 16 for "bypass" water, just like the other transition pieces shown in the figures.

In the fuel bundle shown in Figures 3-6, four horizontal support surfaces 13 directed upwards for a square throttling disk 14 are present in the lower half of a section of a transition piece 15 embodied with essentially square cross section, and that is in the center of the four sides of the square. The throttling disk 14 has four legs 17, which are directed vertically upwards and which are welded tight to one of the four sides of the square of the throttling disk. The throttling disk 14 rests on the support surfaces 13 by means of four leaf springs 18 each contacting a support surface 13 and mounted on the throttling disk 14. Each leg 17 has a radial projection 17', which engages in a horizontal groove 17", which is allocated in the projection and which is sunk into the inner wall surface of the transition piece 15. Each of the legs 17 has a horizontal end surface 19. Therefore, because each end surface 19 contacts a horizontal surface of an associated leg pair 2' directed downwards, which belongs to the lower lattice array 2, the throttling disk 14 /7
is held tight in its position. Therefore, because the throttling disk 14 is mounted on the transition piece 15 by the projections 17' and the grooves 17", not only the weight of the lower lattice plate

and the fuel rods, but also the weight of the transition piece 15 and the fuel channel device 1 counteracts an upward movement of the throttling disk 14.

The throttling disk 14 is moved away such that the legs 17 are bent inwards elastically so far that the projections 17' come out of the grooves 17", so that the throttling disk 14 can be moved vertically upwards.

The throttling disk 14 is provided with a large number of passage holes 20, preferably at least eight, for a water flow supplied to the fuel rods.

Therefore, because the distance between the throttling disk 14 and the lower lattice array 2 is relatively large, the water flowing through the holes 20 can be distributed uniformly over the cross section of the transition piece before it passes the lower lattice array. The inlet part of the transition piece is designated 9'.

The fuel bundle shown in Figures 7 and 8 has a transition piece 25, whose lower part is provided with a circular, ring-shaped throttling disk 22. The throttling disk 22 is surrounded by the inlet part of the transition piece and rests on a circular, ring-shaped flange 23, which is arranged in the inlet part. The ability of the throttling disk 22 to move upwards is prevented by a safety ring 24, which is set in a horizontal plane and which is arranged in a ring-shaped groove in the inner wall of the transition piece.

In the embodiment of the invention shown in Figure 9, a transition piece 26 is provided, which is configured with an integrated cylindrical inlet part 27, which is provided with internal threads and in which a throttling element 28 is screwed in. The throttling element consists of a circular cylindrical part provided with external threads with an external flange 30 on the lower end and an inner circular throttling disk 31 near the upper end, which is an integrated component of the throttling element 28 and has a central circular hole 32. /8

A control element provided with three control arms 33 is mounted on the throttling element 28. The upper ends of the control arms 33 are welded tight on the surface of the flange pointed downwards, and that is in uniform distribution over the periphery (120°). The lower ends of the control arms 33 are connected to each other at a central point under the flange 30. The end surface of the circular cylindrical part 29 pointed upwards is at least partially overlapped by the surface 34 of a ring-shaped shoulder formed in the transition piece 26.

In the embodiment shown in Figures 10 and 11, the transition piece of the fuel bundle is designated 35. The transition piece 35 has an inlet part 36 with an inner circular cylindrical surface 37. Two smaller spacers 38 and a larger spacer 39 are welded tight to the surface 37. The spacers 38 and 39 have contact surfaces, which point downwards and which contact the top side of a throttling disk 40. The throttling disk 40 is fixed in the shown position with the aid of a through bolt 41, which is screwed tight in a threaded hole in the spacer 39. The throttling disk 40 has a larger hole 42, four smaller holes 43, and also a slot 44 for passage of the reactor coolant

supplied to the fuel bundle. The slot 44 is wider than the peripheral length of the side of at least one of the arms 10 in the vicinity of the end surface of the transition piece 35, while the radial length of the slot 44 equals at least 40% of the radius of the throttling disk 40. During mounting, /9 the throttling disk 40 is brought into such an angular position that the slot 44 surrounds one of the arms 10, whereby the throttling disk is turned by this arm.

A fuel bundle according to the invention can consist of four partial bundles, wherein the partial bundles are each arranged in a corresponding partial fuel channel. This can consist of a special tube or it can be configured as one-fourth of the mentioned fuel channel device divided by internal walls.

nachgereicht

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FIG. 1

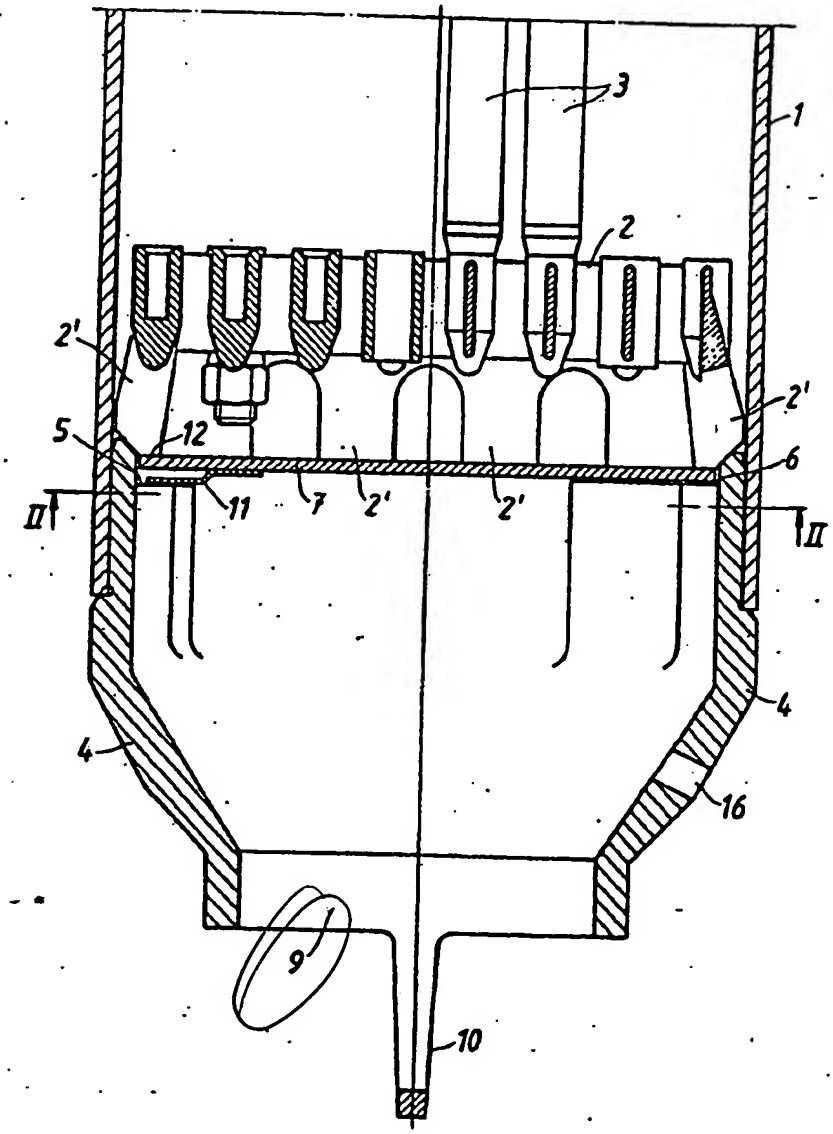

FIG. 2

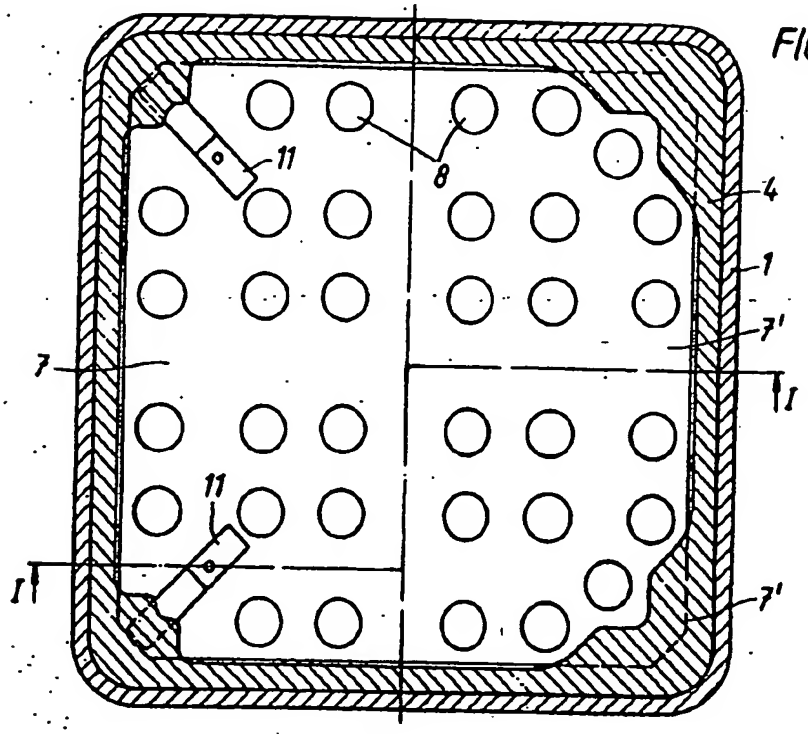

FIG. 4

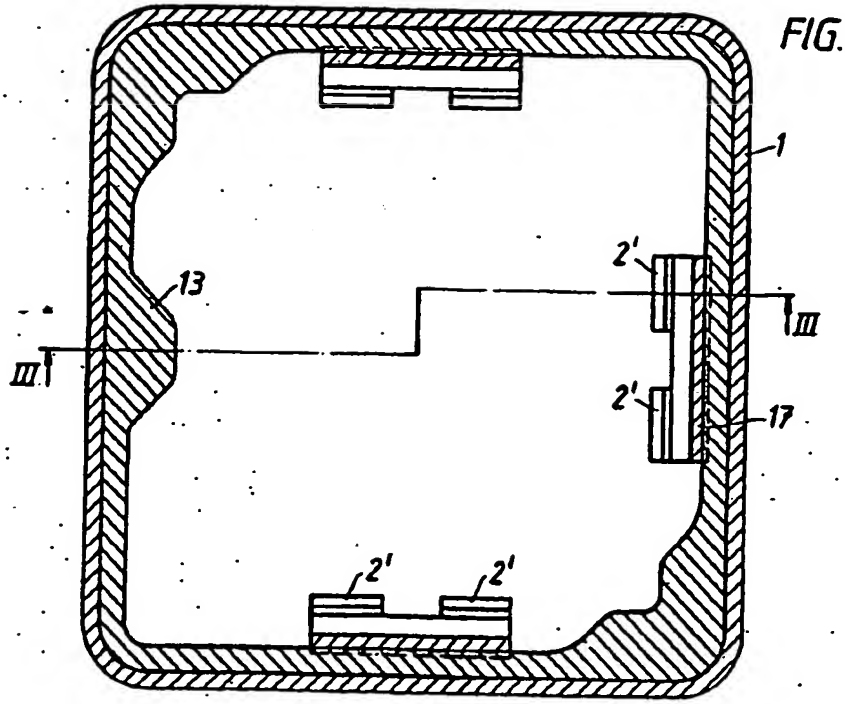

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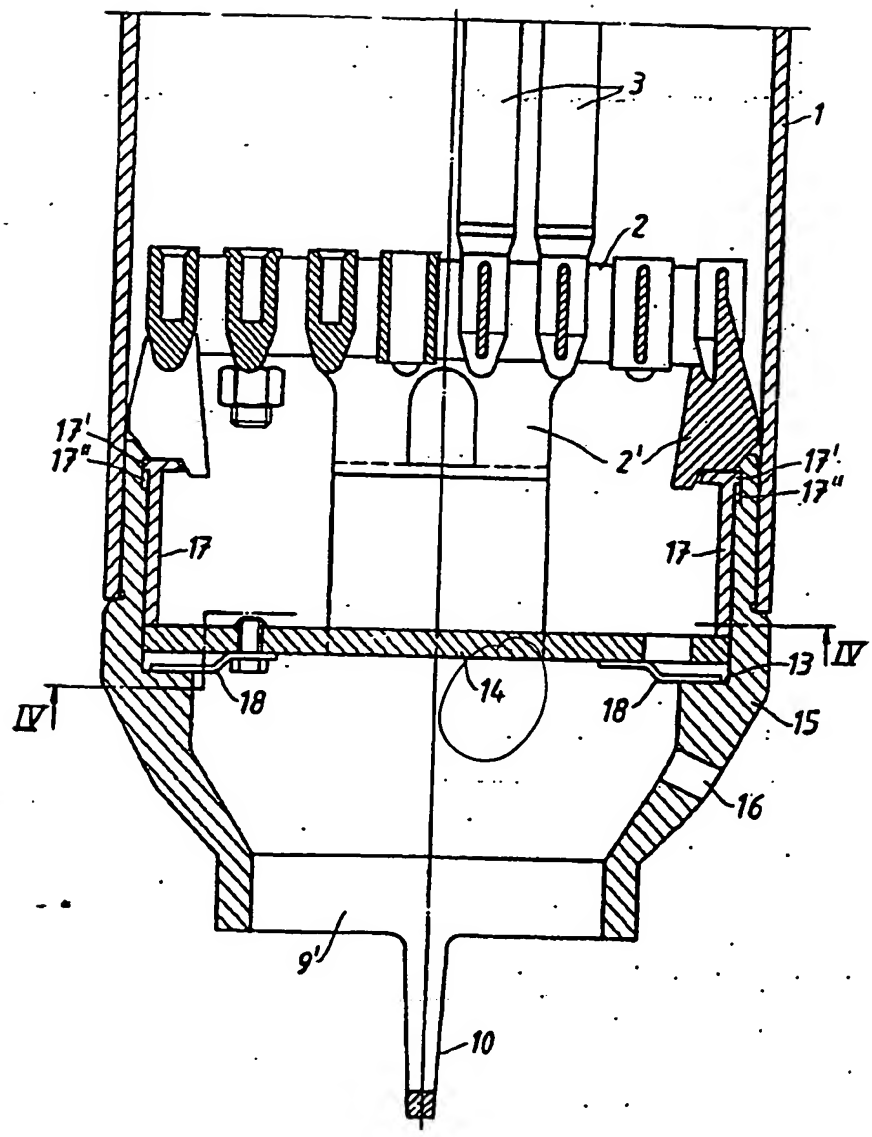
FIG. 3



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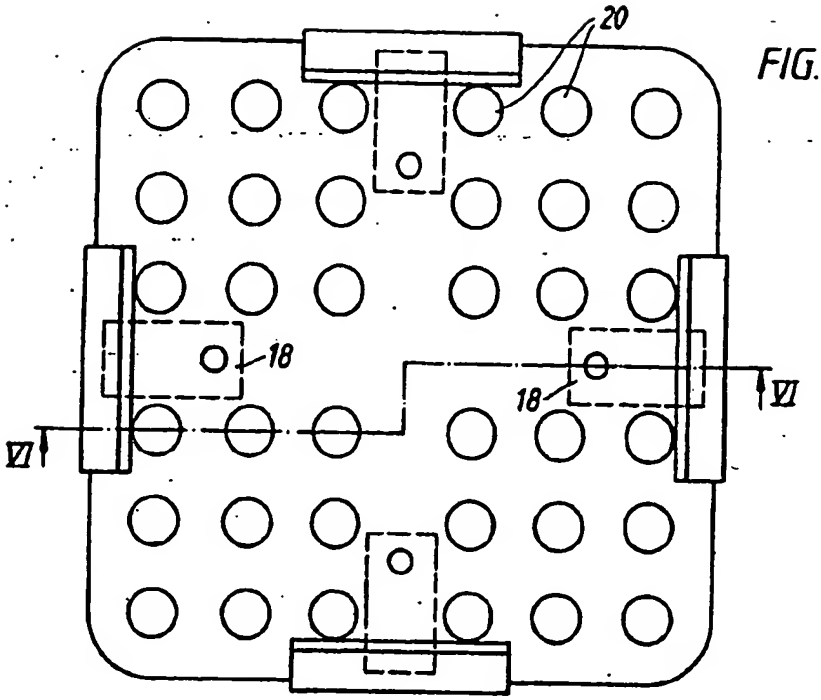

FIG. 5

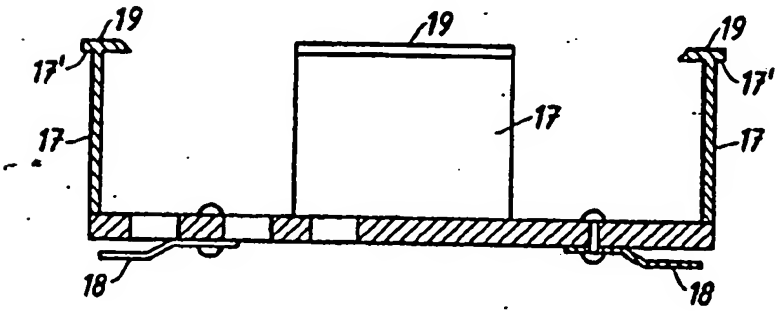

FIG. 6

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FIG. 7

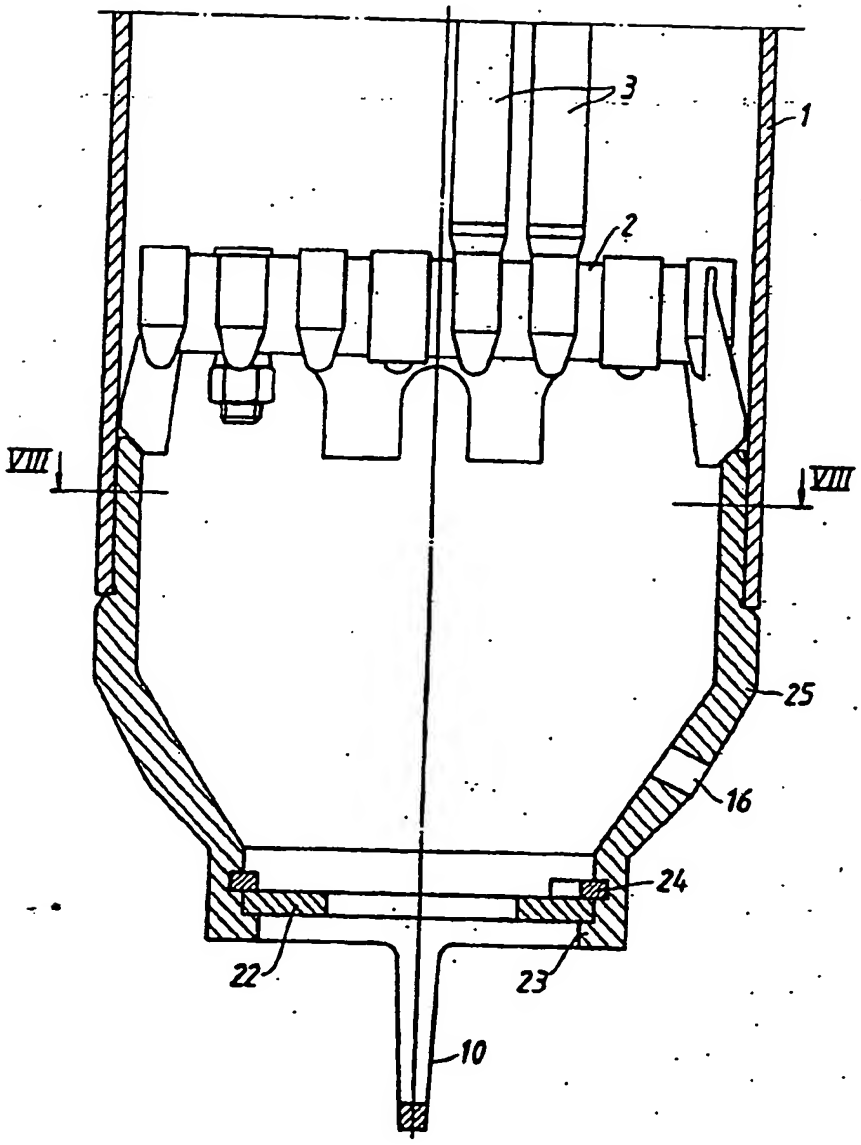

FIG. 8

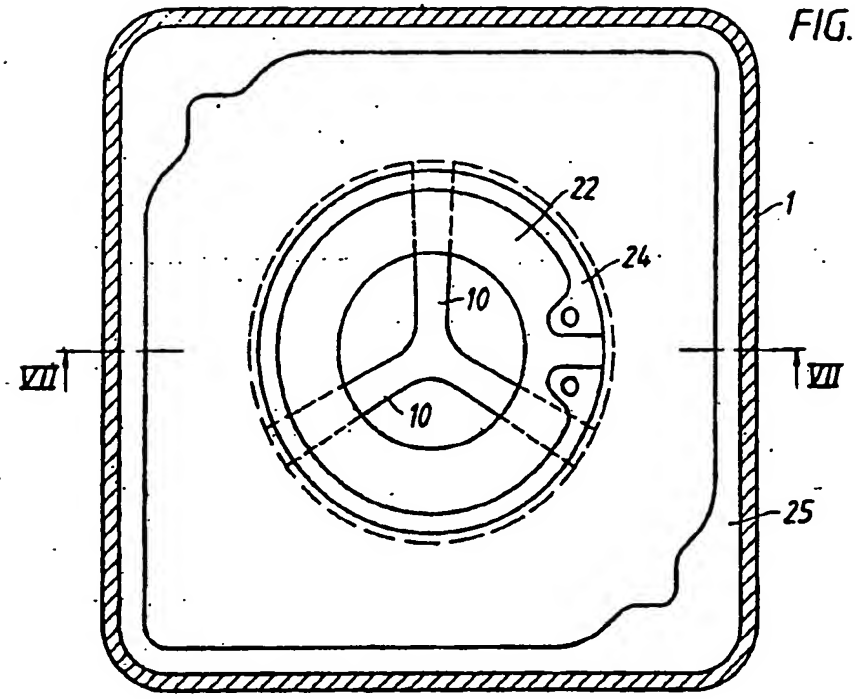

FIG. 9

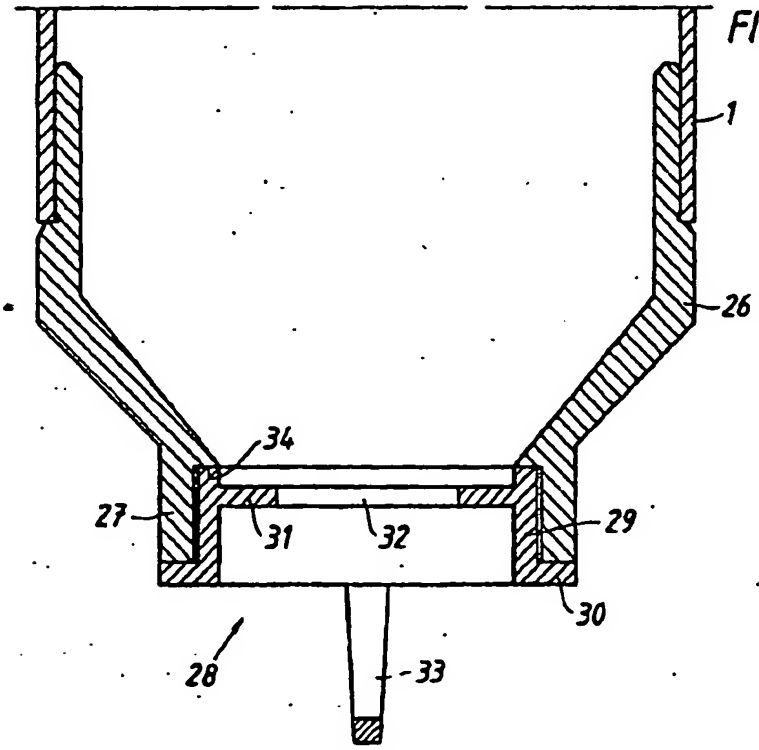

FIG. 10

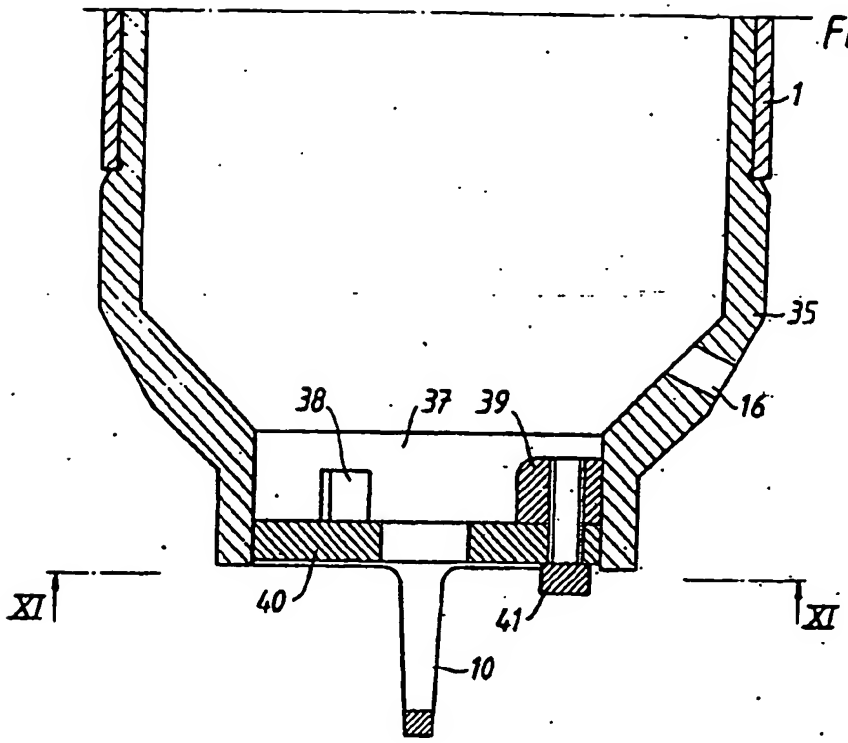

FIG. 11